

# **Needs To Know**

## **For**

### **A, B, & C Distribution**

#### **System Operators**

**Prepared by the Water Board of Education and Examiners of the NC AWWA-WEA in Cooperation with the North Carolina Water Treatment Facility Operators Certification Board and the North Carolina Division of Environmental Health, Department of Environment and Natural Resources.**

**5/21/2019**

<b>Table of Contents (by Reference):</b>	
WSO Water Distribution AWWA (1 <sup>st</sup> Edition), Grades 1 & 2	pages 3-32
WSO Water Distribution AWWA (1 <sup>st</sup> Edition), Grades 3 & 4	pages 3-32
Rules Governing Public Water Systems Title 15A, NC Administrative Code Subchapter 18C	pages 33-34
Rules Governing Water Treatment Facility Operators Title 15A, NC Administrative Code Subchapter 18D	page 35
Math Review Guide	page 36

## References

1. WSO Water Distribution, Grades 1 & 2, AWWA (1<sup>st</sup> Edition)
2. WSO Water Distribution, Grades 3 & 4, AWWA (1<sup>st</sup> Edition)
3. Rules Governing Public Water Systems, North Carolina Administrative Code, Title 15A, Subchapter 18C - *(Can be downloaded from <https://deq.nc.gov/about/divisions/water-resources/planning/classification-standards/rules>).*
4. Rules Governing Water Treatment Facility Operators, North Carolina Administrative Code, Title 15A, Subchapter 18D - *(Can be downloaded from <https://deq.nc.gov/about/divisions/water-resources/planning/classification-standards/rules>).*

## How To Use This Outline

The outline is not a list of facts; therefore, it cannot be studied by itself. The entire manual should then be read and particular attention given to the highlighted sections. The individual is responsible for knowing this material for the examination.

If the operator is deficient in basic math skills, it is recommended courses be taken in the community college system, or elsewhere, to correct the deficiency.

The operator should not expect to study and learn the material necessary to be a distribution system operator or pass the certification examinations in a short period of time, such as the annual school. The annual school is only intended as a review. Distribution system techniques continually change and continuous study is required even after certification. Study of the outlined material and on the job training is recommended. The manuals are designed as a self-teaching guide and can be studied at the operator's own study rate.

<b>Topic</b> WSO Water Distribution	<b>Grades 1&amp;2 Page</b>	<b>Grade 3 &amp; 4 Page</b>	<b>C</b>	<b>B</b>	<b>A</b>
<b>USEPA Drinking Water Regulations</b>	<b>1 - 19</b>	<b>1 - 23</b>			
<b>Federal Regulations</b>	1 - 9				
Safe Drinking Water Act Requirements	1 - 2				
State Primacy	2				
Classes of Public Water Systems	2 - 3				
Regulation of Contaminants	3				
Public Notification	3 - 4				
Monitoring and Reporting	4				
Water Quality Monitoring	4 - 8				
Methods of Collecting Samples	5				
Sample Storage and Shipment	6				
Sample Point Selection	6				
Sample Faucets	6 - 7				
Sample Collection	7 - 8				
Special Purpose Samples	8				
Laboratory Certification	8				
Consumer Confidence Reports	8				
USEPA Regulation Information	9				
<b>State Regulations</b>	9 - 10				
Operator Certification	9				
Cross-Connection Control	9				
Construction Approval	9				
Technical Assistance	10				
Enforcement	10				
<b>Types of Water Systems</b>		1 - 2			
<b>Disinfection By-product and Microbial Regulations</b>		2 - 23			
<b>Requirements of Special Interest to Distribution System Operators</b>	10 - 19				
Total Coliform Rule (TCR) & Revised Total Coliform Rule (RTCT)	10 - 12				
Disinfectant and Disinfection By-product Rules (DBPR)	12	10 – 15			
Stage 1 DBPR	12	10 - 12			
Stage 2 DBPR	13 - 14	12 - 13			
Enhanced Coagulation Requirement of the Stage 1 DBPR and Stage 2 DBPR		13 - 14			
Bromate		14 - 15			

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>USEPA Drinking Water Regulations</b>	<b>1 - 19</b>	<b>1 - 23</b>			
Chlorite		15			
Residual Disinfectants		15			
Surface Water Treatment Rule (SWTR)	14	15 - 17			
Interim Enhanced SWTR	14				
Sanitary Surveys	14 - 15	16 - 17			
C x T Requirements		17			
Long-Term 1 (LT1ESWTR)	15				
Long Term 2 (LT2ESWTR)	15 - 16	17			
Lead and Copper Rule (LCR)	16 - 17	20 - 21			
Filter Backwash Recycle Rule (FBRR)		17 - 18			
Ground Water Rule (GWR)	17	18			
Total Coliform Rule (TCR) and Revised Total Coliform Rule (RTCR)		18 - 20			
Chemical Contaminant Rules		21			
Public Notification Rule		21			
Unregulated Contaminant Monitoring Rule (UCMR)		22			
Operator Certification		22			
Arsenic MCL		22			
Radionuclides Rule		23			
Analytical Methods		23			
National Secondary Drinking Water Regulations	18 - 19				
<b>Operator Math</b>	<b>21 - 66</b>	<b>27 - 54</b>			
<b>Volume Measurements</b>	21 - 28				
Rectangles, Triangles, and Circles	22 - 26				
Cones and Spheres	26 - 28				
<b>Conversions</b>	28 - 51				
Conversion Tables	28 - 29				
Box Method	30 - 31				
Conversions of US Customary Units	31 - 40				
Conversions From Cubic Feet to Gallons to Pounds	31 - 33				
Flow Conversions	31 - 36				
Linear Measurement Conversions	36				
Area Measurement Conversions	37 - 38				
Volume Measurement Conversions	38 - 40				

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Operator Math</b>	<b>21 - 66</b>	<b>27 - 54</b>			
Concentration Conversions	40 - 42				
Milligrams per Liter to Grains per Gallon	40 - 41				
Milligrams per Liter to Parts per Million	41 - 42				
Metric System Conversions	42 - 49				
Metric to Metric Conversions	43 - 47				
Cross-System Conversions	47 - 49				
Temperature Conversions	49 - 51				
<b>Per Capita Water Use</b>	<b>52 - 53</b>				
<b>Average Daily Flow</b>	<b>53 - 57</b>				
<b>Basic Pipeline Disinfection Calculations</b>	<b>57 - 59</b>				
Flushing Rate	57 - 58				
Tablet Method	58				
Chlorination Feed Rate	58 - 59				
<b>Basic Storage Facility Disinfection Calculations</b>	<b>59 - 61</b>				
Storage Facility Volume	59				
Storage Facility Walls Surface Area	59				
Chlorination Spray Solution	60				
Chlorine Amount for Full Facility Method	60				
Chlorine Amount for Chlorinate-and-Fill Method	61				
<b>Calculating Heads</b>	<b>61 - 63</b>				
<b>Instantaneous Flow Rate Calculations</b>	<b>63 - 66</b>				
<b>Piezometric Surface and Hydraulic Grade Line</b>		<b>27 - 35</b>			
Piezometric Surface		27 - 28			
Hydraulic Grade Line		29 - 35			
Locating HGLs From Piezometric Surface Information		29 - 32			
Locating HGLs From Pressure Gauge Information		33 - 35			
<b>Head Loss</b>		<b>35 - 38</b>			
Friction Head Loss		35 - 38			
<b>Pumping Rates</b>		<b>38 - 39</b>			
<b>Pump Heads</b>		<b>39 - 42</b>			
Suction and Discharge		39 - 40			
Static Heads		40			
Dynamic Heads		41 - 42			
<b>Horsepower</b>		<b>43 - 45</b>			

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Operator Math</b>	<b>21 - 66</b>	<b>27 - 54</b>			
Efficiency		45 - 48			
<b>Reading Pump Curves</b>		48 - 51			
Description of Pump Curves		48 - 50			
The H-Q Curve		49			
The P-Q Curve		49 - 50			
The E-Q Curve		50			
Reading the Curve		50 - 51			
<b>Calculations for Chlorine Dosage, Demand, Residual, and Contact Time</b>		51 - 54			
<b>Water Use and System Design</b>	<b>69 - 86</b>	<b>57 - 63</b>			
<b>Water Use</b>	69 - 73				
Domestic Use	69				
Industrial Use	69 - 70				
Public Use	71				
Variations in Water Use	71 - 73				
Time of Day and Day of Week	71				
Climate and Season	71 - 72				
Type and Size of Community	72				
Metering	72 - 73				
Dependability and Quality of Water	73				
Sewer Connection	73				
Condition of the Water System	73				
Industrial Use	69 - 70				
Public Use	71				
<b>Water Rights</b>	73 - 76				
Allocation of Surface Water	74 - 75				
Riparian Doctrine	74				
Prior Appropriation Doctrine	74 - 75				
Priority in Time	75				
Beneficial Use	75				
Legal Complications	75				
Allocation of Groundwater	75 - 76				
Absolute Ownership	75 - 76				
Reasonable Use	76				

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Water Use and System Design</b>	<b>69 - 86</b>	<b>57 - 63</b>			
Correlative Rights	76				
Appropriation-Permit System	76				
<b>Distribution System Purpose and Planning</b>	77 - 81		X	X	X
<b>Water Source Effects on System Design</b>		57 - 59	X	X	X
Types of Water Systems	77 - 79		X	X	X
Surface Water Systems	77 - 78	57	X	X	X
Groundwater Systems	78	57 - 58	X	X	X
Purchased Water Systems	78 - 79	58	X	X	X
Rural Water Systems		58 - 59	X	X	X
System Planning Issues	79		X	X	X
Policy considerations	79		X	X	X
Drinking Water Supply and Distribution System	79 - 81		X	X	X
<b>System Layout</b>	82		X	X	X
<b>Types of Water System Layout</b>		59 - 60	X	X	X
Arterial-Loop System	82		X	X	X
Grid System	82		X	X	X
Tree System	82		X	X	X
Dead Ends	82	60	X	X	X
Valves and Hydrants		60	X	X	X
<b>Mapping</b>	83		X	X	X
<b>Valving</b>	83 - 84		X	X	X
<b>Sizing Mains</b>	84 - 86	60 - 63	X	X	X
Water Use Terms		61	X	X	X
Residential and Commercial Water Use		61	X	X	X
Quantity Requirements	85		X	X	X
Domestic Use	85		X	X	X
Fire Flow Requirements	85	61 - 62	X	X	X
Pressure Requirements	85 - 86	62	X	X	X
Velocity Requirements	86	62	X	X	X
Network Analysis	86	62 - 63	X	X	X
Quality Requirements	86	62	X	X	X
<b>Hydraulics</b>	<b>89 - 97</b>	<b>65 - 72</b>			
<b>Fluids at Rest and in Motion</b>	89 - 90			X	X
Static Pressure	89			X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Hydraulics</b>	<b>89 - 97</b>	<b>65 - 72</b>			
Dynamic Pressure	89 - 90			X	X
Velocity	90			X	X
<b>Measuring Pressure</b>	90 - 94			X	X
<b>Head</b>	95 - 97			X	X
Types of Head	95 - 97			X	X
Pressure Head	95 - 96			X	X
Elevation Head	96			X	X
Velocity Head	96 - 97			X	X
<b>Fluids at Rest and in Motion</b>		65 - 69		X	X
Static Pressure		65		X	X
Dynamic Pressure		65 - 66		X	X
Velocity		66		X	X
Friction Loss		66 - 69		X	X
<b>Hydraulic Gradient</b>		69 - 70		X	X
<b>Hydraulic Transients</b>		70 - 72		X	X
Water Hammer		70		X	X
Surge Control		71 - 72		X	X
<b>Pipe</b>	<b>99 - 120</b>				
<b>Pipe Material Selection</b>	99 - 104				
ANSI/AWWA Standards	100				
ANSI/NSF Standard 61 and Certification	100 - 101				
Selecting Pipeline Material	101 - 104		X	X	X
Pipe Characteristics	101 - 103		X	X	X
Strength	101 - 102		X	X	X
Pressure Rating	102		X	X	X
Durability	102		X	X	X
Corrosion Resistance	102		X	X	X
Smoothness of the Inner Surface	103		X	X	X
Ease of Tapping and Repair	103		X	X	X
Water Quality maintenance	103		X	X	X
Economics	103 - 104		X	X	X
Piping Systems	104		X	X	X
<b>Types of Pipe Materials</b>	105 - 120		X	X	X
Ductile-Iron Pipe	108 - 111		X	X	X



Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Pipe</b>	<b>99 - 120</b>				
Ductile-Iron Pipe Joints	109 - 111		X	X	X
Mechanical Joints	110		X	X	X
Ball-and-Socket Joints	110		X	X	X
Push-on Joints	110		X	X	X
Restrained Joints	110		X	X	X
Grooved and Shouldered Joints	111		X	X	X
Fittings for Iron Pipe	111		X	X	X
Steel Pipe	112 - 114		X	X	X
Advantages and Disadvantages	112 - 113		X	X	X
Steel Pipe Joints and Fittings	113 - 114		X	X	X
Steel Plant Piping	114		X	X	X
Plastic Pipe	114 - 117		X	X	X
Plastic materials	115		X	X	X
Permeation	115		X	X	X
PVC Pipe	115 - 116		X	X	X
PVC Joints and Fittings	116		X	X	X
PE and PB Pipe	116		X	X	X
Fiberglass Pressure Pipe	116 - 117		X	X	X
Concrete Pipe	117 - 120		X	X	X
Prestressed Concrete Pipe	117 - 118		X	X	X
Bar-Wrapped Concrete Cylinder Pipe	119		X	X	X
Reinforced Concrete Cylinder Pipe	119		X	X	X
Reinforced Concrete Noncylinder Pipe	120		X	X	X
Joints and Bends	120		X	X	X
<b>Water Main Installation and Rehabilitation</b>	<b>123 - 150</b>				
<b>Pipe Shipment</b>	123 - 124		X	X	X
<b>Pipe Handling</b>	124 - 127		X	X	X
Pipe and Fitting Inspection	124		X	X	X
Unloading	124 - 126		X	X	X
Stacking	125 - 126		X	X	X
Stringing	126 - 127		X	X	X
<b>Excavation</b>	127 - 138				
Preparations for Excavation	127 - 128		X	X	X
Trenching	128 - 131				

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Water Main Installation and Rehabilitation</b>	<b>123 - 150</b>				
trenching considerations	128		X	X	X
Trench Depth	128 - 129			X	X
Trench Width	129			X	X
Trenching Operations	129 - 131			X	X
Special Excavation Problems	131				X
Rock Excavation	131				X
Poor Soil	131				X
Groundwater	131				X
Avoiding Trench-Wall Failure	131 - 136		X	X	X
Types of Soil	131 -132		X	X	X
Causes of Trench Failure	132		X	X	X
Danger Signs	132 - 133		X	X	X
Methods of Preventing Cave-In	133 - 136		X	X	X
Sloping	133		X	X	X
Shielding	133 - 134		X	X	X
Shoring	134 - 135		X	X	X
Sheeting	135 - 136		X	X	X
Avoiding Other Utilities	136 - 137			X	X
Bedding	137- 138			X	X
<b>Laying Pipe</b>	<b>138 - 150</b>				
Inspection and Placement	138 - 139		X	X	X
Inspection	138		X	X	X
Cleaning	138		X	X	X
Placement	139		X	X	X
Jointing	139 - 142		X	X	X
Push-on Joints	139 - 141		X	X	X
Mechanical Joints	142		X	X	X
Connecting to Existing Mains	142 - 146			X	X
Tee Connections	142 - 144			X	X
Pressure Taps	144 - 146			X	X
Tunneling	146				X
Thrust Restraints	147 - 148				
Thrust Locations	147		X	X	X
Thrust Control	147 - 148			X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Water Main Installation and Rehabilitation</b>	<b>123 - 150</b>				
Air Vents	149 - 150				X
<b>Backfilling, Main Testing, and Installation Safety</b>	<b>153 - 167</b>				
<b>Backfilling</b>	153 - 155		X	X	X
Placing Backfill	153		X	X	X
Compacting	153 - 155		X	X	X
Tamping	153 - 154		X	X	X
Saturating With Water	154		X	X	X
Granular Backfill	154 - 155		X	X	X
Shoring Removal	155		X	X	X
Backfilling and Tamping Equipment	155		X	X	X
<b>Pressure and Leak Testing</b>	156 - 158		X	X	X
Testing Procedure	156 - 157		X	X	X
Measuring Makeup Water	157 - 158		X	X	X
Failed Pressure Tests	158		X	X	X
<b>Flushing and Disinfection</b>	158 - 162		X	X	X
Flushing	159		X	X	X
Disinfection	159		X	X	X
Application Point	159		X	X	X
Chlorine Dosage	159 - 160		X	X	X
Procedures	160 - 161		X	X	X
Contact Period	161		X	X	X
Bacteriological Testing	161 - 162		X	X	X
<b>Final Inspection</b>	162		X	X	X
<b>Site Restoration</b>	162 - 164		X	X	X
Backfilling Trenches	162		X	X	X
Pavement Repair	162		X	X	X
Grass Replacement	163		X	X	X
Ditches and Culverts	163		X	X	X
Trees and Shrubs	163		X	X	X
Utilities	163		X	X	X
Curbs, Gutters, and Sidewalks	163		X	X	X
Machinery and Construction Sheds	163		X	X	X
Watercourses and Slopes	164		X	X	X
Roadway Cleanup	164		X	X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Backfilling, Main Testing, and Installation Safety</b>	<b>153 - 167</b>				
Traffic Restoration	164		X	X	X
Restoration of Private Property	164		X	X	X
<b>Water Main Installation Safety</b>	<b>164 - 167</b>		X	X	X
Material-Handling Safety	164		X	X	X
Trench Safety	165		X	X	X
Traffic Control Safety	165 - 166		X	X	X
Personal Protection Equipment	165		X	X	X
Chemical Safety	166		X	X	X
Portable Power Tool Safety	166		X	X	X
Vehicle Safety	167		X	X	X
<b>Water Services</b>	<b>169 - 181</b>				
<b>Meter Locations</b>	<b>169 - 171</b>		X	X	X
Exposed Meters	169		X	X	X
Meter Boxes	169 - 170		X	X	X
Meter Located In Buildings	171		X	X	X
<b>Service Line Sizes, Materials, and Equipment</b>	<b>171 -</b>		X	X	X
Service Line Size	171		X	X	X
Types of Service Line pipe and Tubing	172 - 173		X	X	X
Lead Pipe	172		X	X	X
Galvanized Iron Pipe	172		X	X	X
Copper Tubbing	172		X	X	X
Plastic Tubbing	172 - 173		X	X	X
Adapters and Connectors	173		X	X	X
Corporation Stops	173		X	X	X
Curb Stops and Boxes	174 - 175		X	X	X
<b>Water Service Taps</b>	<b>175 - 178</b>		X	X	X
Direct Insertion	175 - 176		X	X	X
Service Saddles	177		X	X	X
Small Drilling Machines	177		X	X	X
Self-Contained Taps	177		X	X	X
Tap Location	177 - 178		X	X	X
<b>Leaks and Breaks</b>	<b>179</b>		X	X	X
<b>Thawing</b>	<b>179 - 180</b>			X	X
Electrical Thawing	179			X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Water Services</b>	<b>169 - 181</b>				
Other Methods	180			X	X
Service Line Responsibility	180 - 181		X	X	X
Service Line Records	181		X	X	X
<b>Valves</b>	<b>183 - 198</b>				
<b>Uses of water Utility Valves</b>	<b>183 - 186</b>		X	X	X
Valves to Start and Stop Flow	183		X	X	X
Distribution System isolation Valves	183 - 184		X	X	X
Hydrant Auxiliary Valves	183		X	X	X
Pump Control Valves	184		X	X	X
Water Service Valves	184		X	X	X
Valves for Regulating Pressure and Throttling Flow	184 - 185		X	X	X
Pressure-Reading Valves	184		X	X	X
Altitude Valves	184 - 185		X	X	X
Valves for Preventing Backflow	185		X	X	X
Valves for Relieving Pressure	185 - 186		X	X	X
Pressure-Relief Valves	185		X	X	X
Air-Relief Valves	186		X	X	X
<b>Classification of Water Utility Valves</b>	<b>187 - 194</b>				
Gate Valves	187 - 190		X	X	X
Nonrising-Stem Gate Valves	188		X	X	X
Rising-Stem Gate Valves	188		X	X	X
Horizontal Gate Valves	188		X	X	X
Bypass Valves	189		X	X	X
Tapping Valves	189- 190		X	X	X
Cutting-In Valves	190			X	X
Inserting Valves	190			X	X
Resilient-Seated Gate Valves	190		X	X	X
Slide Valves	190			X	X
Globe Valves	191			X	X
Needle Valves	191 - 192			X	X
Pressure-Relief Valves	192		X	X	X
Air-and-Vacuum Relief Valves	192			X	X
Diaphragm Valves	192			X	X
Pinch Valves	192			X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Valves</b>	<b>183 - 198</b>				
Rotary Valves	193		X	X	X
Butterfly Valves	193 - 194		X	X	X
Check Valves	194		X	X	X
<b>Valve Operation</b>	<b>195 - 196</b>				
Manual Operation	195		X	X	X
Power Actuators	195 - 196			X	X
Electric Actuators	196			X	X
Hydraulic Actuators	196			X	X
Pneumatic Actuators	196			X	X
Actuator Operating Speed	196			X	X
<b>Valve Storage</b>	<b>196</b>		X	X	X
<b>Valve Joints</b>	<b>196 - 197</b>		X	X	X
<b>Valve Boxes and Vaults</b>	<b>197 - 198</b>		X	X	X
<b>Valve Records</b>	<b>198</b>		X	X	X
<b>Fire Hydrants</b>	<b>201 - 215</b>				
<b>Fire Hydrant Uses</b>	<b>201 - 203</b>		X	X	X
Fire Fighting	201 - 202		X	X	X
Miscellaneous Fire Hydrant Uses	202-203		X	X	X
Restricting miscellaneous Uses	202		X	X	X
Allowing Miscellaneous Uses	202 - 203		X	X	X
<b>System Problems Caused by hydrant Operation</b>	<b>203</b>		X	X	X
<b>Types of Fire Hydrants</b>	<b>203 - 206</b>		X	X	X
Dry-Barrel Hydrants	204 - 206		X	X	X
Wet-Top Hydrants	204		X	X	X
Dry-Top Hydrants	204		X	X	X
Valve Types	206		X	X	X
Breakaway Hydrants	205 - 206		X	X	X
Wet-Barrel Hydrants	206		X	X	X
Warm-Climate Hydrants	206		X	X	X
Flush Hydrants	206		X	X	X
<b>Hydrant Parts</b>	<b>207 - 209</b>			X	X
Upper Section	207 - 208			X	X
Lower Section	208			X	X
Auxiliary Valves	208 - 209		X	X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Fire Hydrants</b>	<b>201 - 215</b>			X	X
<b>Inspection and Installation</b>	209 - 211				
Inspection of new Hydrants	209			X	X
Installation Procedures	210 - 211			X	X
Location	210			X	X
Footing and Blocking	210			X	X
Drainage	210			X	X
Hydrant Painting	210 - 211			X	X
Testing	211			X	X
<b>Operation and Maintenance</b>	212 - 214			X	X
Hydrant Operation	212			X	X
Hydrant Maintenance	212			X	X
Inspection Procedures	212 - 213			X	X
Hydrant Repair	213			X	X
Flow Testing	214			X	X
<b>Hydrant Records</b>	214			X	X
<b>Hydrant Safety</b>	214 - 215			X	X
<b>Water Storage</b>	<b>217 - 237</b>				
<b>Water Storage Requirements</b>	217 - 220				X
Purposes of Water Storage	217 - 220			X	X
Equalizing Supply and Demand	217 - 218			X	X
Increasing Operating Convenience	218			X	X
Leveling Out Pumping Requirements	218 - 219			X	X
Decreasing Power Cost	219			X	X
Providing Water During Source or Pump Failure	219			X	X
Providing Water to Meet Fire Demands	219			X	X
Providing Surge Relief	219			X	X
Increasing Detention Times	220			X	X
Blending Water Sources	220			X	X
Capacity Requirements	220			X	X
<b>Types of Treated-Water Storage Facilities</b>	220 - 224				
Type of Service	220 - 221			X	X
Configuration	221 - 222			X	X
Elevated Tanks	221			X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Water Storage</b>	<b>217 - 237</b>				
Standpipes	221			X	X
Reservoirs	221 - 222			X	X
Hydropneumatic Systems	222			X	X
Type of Construction Material	222 - 224			X	X
Earth-Embankment Reservoirs	222 - 223			X	X
Steel Tanks	223 - 224			X	X
Concrete Tanks and Reservoirs	224			X	X
<b>Location of Distribution Storage</b>	<b>225 - 227</b>				
Elevated Storage	225 - 226				X
Relationship to System Hydraulics	225 - 226				X
Minimizing Pumping and Transmission Costs	226				X
Aesthetic Concerns	226				X
Ground-Level Storage	226 - 227				X
<b>Water Storage Facility Equipment</b>	<b>227 - 233</b>				
Elevated Storage Tanks	227 - 232				X
Inlet and Outlet Pipes	227				X
Overflow Pipe	228				X
Drain Connection	228				X
Monitoring Devices	228				X
Valving	228 - 229				X
Air Vents	229				X
Access Hatched	229				X
Ladders	229				X
Coatings	230 - 231				X
Cathodic Protection	231 - 232				X
Obstruction Lighting	232				X
Ground-Level Storage Facilities	232 - 233				X
Inlet and Outlet Pipes	232				X
Overflow Pipes, Vents, and Hatches	232 - 233				X
Drains	233				X
Corrosion Protection	233				X
<b>Operation and Maintenance of Water Storage Facilities</b>	<b>233 - 236</b>				
Cold-Weather Operation	233 - 234			X	X
Basic Maintenance	234 - 236			X	X



Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Water Storage</b>	<b>217 - 237</b>				
Elevated Tanks	234			X	X
Ground-Level Tanks	234			X	X
Disinfection	234 - 236			X	X
Inspection	236			X	X
Records	236			X	X
<b>Water Storage Facility Safety</b>	236 - 237			X	X
<b>Electrical and Instrumentation-and-Control Systems</b>	<b>239 - 252</b>	<b>75 - 88</b>			
<b>Electricity and Magnetism</b>	239 - 241				
Static Electricity	239				
Dynamic Electricity	239 - 240				
Direct Current	239				
Alternating Current	239 - 240				
Induced Current	240				
Electromagnetics	240 - 241				
<b>Electrical Measurements and Equipment</b>	241 - 242				
<b>Instrumentation and Control Systems</b>	243 - 251				X
Primary Instrumentation – Monitoring Sensors	243 - 247				X
Flow Sensors	243				X
Pressure Sensors	243				X
Level Sensors	243 - 244				X
Temperature Sensors	244 - 245				X
Electrical Sensors	245				X
Equipment Status Monitors	246 - 247				X
Process Analyzers	246 - 247				X
Turbidity Monitors	247				X
pH Monitors	247				X
Disinfectant Residual Monitors	247				X
Other Analyzers Used in Distribution Systems	247				X
Secondary Instrumentation	247 - 249	75 - 80			X
Signal Transmission	247	75 - 76			X
Receivers and Indicators	247 - 248	76			X
Telemetry	248	77 - 80			X
Analog Signal Systems		78			X
Digital Signal Systems		78 - 79			X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Electrical and Instrumentation-and-Control Systems</b>	<b>239 - 252</b>	<b>75 - 88</b>			
Multiplexing	248 - 249	79			X
Transmission Channels	249	77 - 78			X
Scanning		79			X
Polling		79			X
Duplexing		80			X
<b>Control Systems</b>	249 - 251	80 - 84			X
Control Classifications		80 - 83			X
Direct Manual Control	249	81			X
Remote Manual Control	249	81 - 82			X
Semiautomatic Control	249	82			X
Automatic Control	250 - 251	82 - 83			X
Direct Wire and Supervisory Control		84			X
<b>Supervisory Control and Data Acquisition</b>	251 - 252	84 - 85			X
Master Station		84			X
Centralized Computer Control		84			X
Distributed Computer Control		84			X
Human-Machine Interface		84 - 85			X
The Future of Supervisory Control		85			X
<b>Operation and Maintenance</b>		86 - 88			X
Maintenance of Sensors and Transmitters		86 - 87			X
Pressure Sensors		86			X
Flowmeters		86			X
Transmitters		86 - 87			X
Maintenance of Receivers and Indicators		87			X
Troubleshooting Guidelines		87			X
Maintenance Records		87 - 88			X
<b>Motors and Engines</b>	<b>255 - 259</b>	<b>91 - 99</b>			
<b>Motors</b>	255 - 257				X
Single-Phase Motors	255 - 256				X
Three-Phase Motors	256				X
Motor Temperature	256				X
Mechanical Protection	256 - 257				X
<b>Motor Control Equipment</b>	257				X
Motor Starters	257				X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Motors and Engines</b>	<b>255 - 259</b>	<b>91 - 99</b>			
Reduced-Voltage Controllers	257				X
Motor Control Systems	257				X
<b>Internal-Combustion Engines</b>	<b>258 - 259</b>				X
Gasoline Engines	258				X
Diesel Engines	258				X
Gas Engines	258				X
Steam Engines	258				X
Operation and Maintenance	259				X
<b>Pump, Motor, and Engine Records</b>	<b>259</b>				X
<b>Motor Protection Equipment</b>		91 - 92			X
<b>Improving the Efficiency of Electrically Driven Pumps</b>		92 - 94			X
Reducing Total Electric Power Usage		92			X
Reducing Peak-Demand Charges		93			X
Using Gravity-Feed Storage		93			X
Using Engine-Driven Pumps		93			X
Reducing Peak Water Usage		93			X
Changing the Time of Demand		93			X
Power-Factor Improvement		93 - 94			X
Changing the Motor Type		94			X
Changing the Motor Loading		94			X
Using Capacitors		94			X
<b>Maintenance of Electric Motors</b>		94 - 97			X
Housekeeping		95			X
Alignment and Balance		95			X
Lubrication		95 - 96			X
Brushes		96			X
Slip Rings		96			X
Insulation		96			X
Connections, Switches, and Circuitry		97			X
Phase Imbalance		97			X
<b>Motor and Engine Safety</b>		97 - 99			X
Electrical Devices		98			X
Fire Safety		99			X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Pumps and Pumping Stations</b>	<b>261 - 278</b>				
<b>Type of Pumps</b>	261 - 267			X	X
Velocity Pumps	261 - 266			X	X
Velocity Pump Design Characteristics	262			X	X
Radial-Flow Designs	262			X	X
Axial-Flow Designs	262 - 263			X	X
Mixed-Flow Designs	263			X	X
Centrifugal Pumps	263 - 264			X	X
Vertical Turbine Pumps	264 - 266			X	X
Deep- Well Pumps	265			X	X
Submersible Pumps	265			X	X
Booster Pumps	265 - 266			X	X
Centrifugal-Jet Pump Combination	266			X	X
Positive-Displacement Pumps	266 - 267			X	X
Reciprocating Pumps	267			X	X
Rotary Pumps	267			X	X
<b>Operation of Centrifugal Pumps</b>	268 - 271			X	X
Pump Starting and Stopping	268 - 270			X	X
Pump Starting	268			X	X
Pump Stopping	269 - 270			X	X
Flow Control	270			X	X
Monitoring Operational Variables	270 - 271			X	X
Suction and Discharge Heads	270			X	X
Bearing and Motor Temperature	270 - 271			X	X
Vibration	271			X	X
Speed	271			X	X
General Observations	271			X	X
<b>Mechanical Details of Centrifugal Pumps</b>	271 - 277				X
Casing	272				X
Single-Suction Pumps	272				X
Double Suction Pumps	272 - 273				X
Impeller	273 - 274				X
Wear Rings	274				X
Shaft	274				X
Shaft Sleeves	275				X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Pumps and Pumping Stations</b>	<b>261 - 278</b>				
Packing Rings	275				X
Lantern Rings	275 - 276				X
Mechanical Seals	276 - 277				X
Bearings	277				X
Couplings	277				X
<b>Centrifugal Pump Maintenance</b>	278				X
<b>Meters</b>	<b>281 - 288</b>	<b>101 - 113</b>			
<b>Customer Water Meters</b>	281 - 284		X	X	X
Positive Displacement Meters	282		X	X	X
Large-Customer Meters	283 - 284		X	X	X
Compound Meters	283		X	X	X
Current Meters	283		X	X	X
Detector-Check Meters	284		X	X	X
<b>Mainline Metering</b>	284 - 288			X	X
Types of Mainline Meters	285 - 288			X	X
Current Meters	285 - 286			X	X
Turbine Meters	285			X	X
Multijet Meters	285			X	X
Propeller Meters	285 - 286			X	X
Proportional Meters	286			X	X
Venturi Meter	286			X	X
Orifice Meters	286			X	X
Magnetic Meters	287			X	X
Ultrasonic Meters	287 - 288			X	X
<b>Customer Meter Installation</b>		101 - 106			
General considerations		101	X	X	X
Manifold Installations		102 - 103		X	X
Meter Connections		103	X	X	X
Indoor Installations		104	X	X	X
Outdoor Installations		105 - 106	X	X	X
Small-Meter Installations		105	X	X	X
Large-Meter Installations		105 - 106		X	X
<b>Meter Reading</b>		106 - 109			
Direct Readout		106 - 107	X	X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Meters</b>	<b>281 - 288</b>	<b>101 - 113</b>			
Remote Reading Devices		107 - 109	X	X	X
Plug-in Readers		108 - 109	X	X	X
Electronic Meter Reading		109	X	X	X
Automatic Meter Reading		109	X	X	X
<b>Meter Testing, Maintenance, and Repair</b>		<b>110 - 113</b>			
Testing New Meters		110		X	X
Frequency Requirements for Testing Meters		111		X	X
Testing Procedures		111 - 112		X	X
Maintenance and Repair		112		X	X
Record Keeping for Meters		112 - 113	X	X	X
<b>Operational Practices</b>		<b>115 - 148</b>			
<b>Operations and Maintenance Practices to Maintain Water Quality</b>		<b>115 - 131</b>	X	X	X
Hydraulic Detention Time		115		X	X
Storage Facility Operation		115 - 116			
Flushing Programs		116 - 119	X	X	X
Flushing Procedures		116 - 118	X	X	X
Directional Flushing		119	X	X	X
Water Main Cleaning		119 - 123	X	X	X
Main-Cleaning Preparation		120			X
Air Purging		120			X
Swabbing		120 - 121			X
Pigging		121 - 122			X
Metal Scrapers		123			X
Power-Driven Cleaning		123			X
Final Cleaning Procedures		123			X
Chlorine Treatment		123	X	X	X
Lining Water Mains		123 - 124			X
Cement-Mortar Lining		123 - 124			X
Slip Lining		124			X
Booster Disinfection		124 - 125			X
Customer Complaints		125			X
Source Water Blending		126			X
Source Water Treatment		126 - 128			X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Operational Practices</b>		<b>115 - 148</b>			
Seasonal Considerations		129			X
Pressure Requirements		129			X
Cross-Connection Control		129 - 130			X
Emergency Operations		130			X
Energy Management		130 - 131			X
Redundant Power Supply		131			X
Pumping Strategies		131			X
Pipeline Friction Loss		131			X
<b>Directional and Velocity Control</b>		131 - 132		X	X
Fire Flow Testing		131			
Pump Startup, Shutdown, and Valve Operation		131 - 132			
<b>Maintaining Flow and Pressure</b>		132	X	X	X
Distribution System Inspection		132 - 134	X	X	X
Pressure and Flow Test		132 - 134	X	X	X
Checking Pressure		133	X	X	X
Checking Loss of Head		133	X	X	X
Checking Flow		133 - 134	X	X	X
Routine Inspection		134	X	X	X
Leak Detection and Repair		134 - 148		X	X
Locating Leaks		134 - 135		X	X
Large Leaks		134		X	X
Small Leaks		134 - 135		X	X
Leak Detection Methods		135 - 138		X	X
Listening Surveys		135 - 136		X	X
Correlator Method		136		X	X
Statistical Noise Analyzer		136 - 137		X	X
Acoustic Leak Detection Procedures		137		X	X
Factors Affecting Leak Detection		138		X	X
Water Audits		138 - 139		X	X
Emergency Leak Repairs		139 - 143	X	X	X
Preliminary Steps		139 - 141	X	X	X
Locating the Leak		141	X	X	X
Excavation		141 - 142	X	X	X
Leak Repair		142 - 143	X	X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Operational Practices</b>		<b>115 - 148</b>			
Restoration		143	X	X	X
Record Keeping		143	X	X	X
External Pipeline Corrosion		143 - 145			X
Factors Affecting External Corrosion		143 - 144			X
Methods of Prevention External Corrosion		144 - 145			X
Bimetallic Corrosion		145 - 146			X
Stray-Current Corrosion		147 - 148			X
<b>Basic Chlorination</b>	<b>289 - 310</b>				
<b>Basics of Chemical Disinfection</b>	289 - 294				
Practical Aspects of Chlorination	290 - 294				
Properties of Chlorine	290 - 291				
Chlorine Reactions	291 - 292				
Chlorination With Hypochlorite	292 - 293				
Breakpoint Chlorination	293 - 294				
<b>Chlorine feed Equipment</b>	294				
<b>Gas Chlorination Facilities</b>	294 - 306				
Handling and Storing Chlorine Gas	295 - 298				
Cylinders	296 - 297				
Ton Containers	297 - 298				
Feeding Chlorine Gas	298 - 303				
Weighing Scales	298				
Valves and Piping	299 - 300				
Chlorinators	301 - 302				
Injectors	302				
Diffusers	302 - 303				
Gas Chlorination Auxiliary Equipment	303 - 306				
Booster Pumps	303				
Automatic Controls	304 - 305				
Flow Proportional Control	304				
Residual flow Control	304				
Evaporators	304 - 305				
Automatic Switchover Systems	305 - 306				
Chlorine Alarms	306				
Safety Equipment	306				



Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Basic Chlorination</b>	289 - 310				
<b>Hypochlorination Facilities</b>	307 - 308				
Hypochlorite Compounds	307 - 308				
Calcium Hypochlorite	307				
Sodium Hypochlorite	308				
Common Equipment	308				
<b>C x T Values</b>	309				
<b>Disinfection By-products</b>	309 - 310				
<b>Booster Disinfection</b>	310				
<b>System Operations</b>	313 - 318				
<b>Maintaining Water Quality</b>	313 - 318		X	X	X
Water Quality Monitoring	314 - 316		X	X	X
Routine Monitoring	314		X	X	X
Development of a Sampling Plan	314 - 315		X	X	X
Nonroutine Monitoring	315 - 316		X	X	X
Finished Water Storage Facilities	315		X	X	X
Customer Complaint Investigations	315		X	X	X
Construction Activities	315		X	X	X
Emergency Monitoring	315 - 316		X	X	X
System Design for Water Quality Enhancement	316 - 318				X
Planning Considerations	316				X
Hydraulic and Water Quality Modeling	316 - 317				X
Pipeline Design	317				X
Pressure Zone Adjustments	317				X
Finish Water Storage Facilities	317 - 318				X
<b>Water Quality Testing</b>	<b>321 - 339</b>	<b>151 - 176</b>			
<b>Sampling</b>	321 - 332				
Importance of Sampling	321				
Types of Samples	321 - 323				
Grab Samples	321 - 322				
Composite Samples	322				
Continuous Sample	323				
Sampling Point Selection	323 - 329				
Distribution System Sample Points	324 - 328				
Sample Faucets	328 - 329				

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Water Quality Testing</b>	<b>321 - 339</b>	<b>151 - 176</b>			
Collection of Samples	329 - 331				
Raw-Water Sample Collection	329 - 330				
Treatment Plant Sample Collection	330				
Distribution System Sample Collection	330 - 331				
Special-Purpose Samples	331 - 332				
<b>Monitoring for Chemical Contaminants</b>	332				
<b>Laboratory Certification</b>	333 - 334				
<b>Record keeping and Sample Labeling</b>	334				
<b>Sample Preservation, Storage, and Transportation</b>	334 - 337				
Preservation and Storage	334 - 335				
Sample-Preservation Techniques	335				
Time of Sampling	335				
Transportation	336				
Chain of Custody	336 - 337				
Field Log Sheet	336				
Sampler's Liability	337				
Sampler's Responsibility	337				
<b>Common Water Quality Tests</b>	337 - 339				
Chlorine (Free or Total)	337				
Coliform	337 - 338				
Nitrate, Nitrite, and Ammonia	338 - 339				
pH	339				
<b>Microbiological Organisms</b>		151 - 157			
Indicator Organisms		151			
Coliform Analysis		151 - 157			
Sampling		152			
Test Methods		152 - 157			
Multiple-Tube Fermentation		153 - 154			
Presumptive Test		153			
Confirmed Test		153			
Complete Test		153 - 154			
Presence-Absence Test		154 - 155			
Fecal Coliform Procedure		155			
E coli Procedure		155			

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Water Quality Testing</b>	<b>321 - 339</b>	<b>151 - 176</b>			
MMO-MUG Technique		155			
Membrane Filter Method		155 - 156			
Heterotrophic Plate Count Procedure		156 - 157			
Alternate Method		157			
<b>Physical and Aggregate Properties of Water</b>		157 - 158			
Calcium Carbonate Stability		157 - 158			
Significance		157 - 158			
Sampling		158			
Methods of Determination		158			
<b>Inorganic Chemicals</b>		159 - 162			
Chlorine Residual and Demand		159 = 161			
Significance		159			
Chlorine Residual		159 = 160			
Chlorine Demand		160 - 616			
Disinfection By-products		161 - 162			
Sampling		161 - 162			
Treatment Plant Sampling		161			
Distribution System Sampling		161 - 162			
Methods of Determination		162			
<b>Organic Chemicals</b>		162 - 165			
Measurements of Organic Compounds		162 - 165			
General Analytical Methods		162 - 163			
Specific Analytical Methods		163 - 165			
Extraction and Concentration		163 - 164			
Separation		164			
Detection		164			
Sampling for Organic Compounds		164 - 165			
Radiological Contaminants		165 - 169			
Radioactive Materials		165 - 167			
Alpha Particles (Radiation)		165 - 166			
Beta Radiation		166			
Gamma Radiation		166			
Unit of Radioactivity		166 - 167			
Radioactive Contaminants in Water		167 - 168			

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Water Quality Testing</b>	<b>321 - 339</b>	<b>151 - 176</b>			
Radium		167 - 168			
Uranium		168			
Radon		168			
Artificial Radionuclides		168			
Adverse Health Effects of Radioactivity		169			
Radionuclides Monitoring Requirements		169			
<b>Customer Inquiries and Complaint Investigation</b>		<b>169 - 176</b>			
General Principles		170 - 171			
Complaint of Inquiry Form		170			
Investigation		171			
Final Disposition		171			
Specific complaints		171 - 176			
Taste and Odor		171 - 173			
Receiving Information		172			
Investigation		172 - 173			
Disposition of the Complaint		173			
Physical Appearance		173 - 174			
Receiving Information		173			
Investigation		173 - 174			
Disposition of the Complaint		174			
Staining of Laundry and Plumbing Fixtures		174 - 175			
Receiving Information		174			
Investigation		175			
Disposition of the Complaint		175			
Illness Caused by Water		175 - 176			
Receiving Information		175			
Investigation		175 - 176			
Disposition of the Complaint		176			
<b>Backflow Prevention and Cross-Connection Control</b>	<b>341 - 361</b>				
<b>Terminology</b>	341		X	X	X
Backflow	341		X	X	X
Cross-Connection	341		X	X	X
<b>Cross-Connection and Locations</b>	342		X	X	X
<b>Types of Cross-Connections</b>	342 - 347		X	X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Backflow Prevention and Cross-Connection Control</b>	<b>341 - 361</b>				
Actual Cross-Connections	343		X	X	X
Potential Cross-Connections	343		X	X	X
Cross-Connection Examples	343 - 347		X	X	X
Backflow due to Backpressure	345		X	X	X
Backflow due to Backsiphonage	345 - 347		X	X	X
<b>Backflow Control Methods and Devices</b>	<b>347 - 356</b>			X	X
Air Gaps	348			X	X
Reduced Pressure Zone Backflow Preventers	348 - 350			X	X
Double Check Valve Assemblies	351			X	X
Vacuum Breakers	351 - 352			X	X
Barometric Loops	352 - 353			X	X
Other Methods and Devices	353 - 354			X	X
Level of Protection	354			X	X
<b>Cross-Connection Control Programs</b>	<b>357 - 360</b>			X	X
Developing a Cross-Connection Control Program	357 - 360			X	X
Program Content	357 - 358			X	X
Procedures	358 - 359			X	X
Backflow-Prevention Devices	359 - 360			X	X
<b>Records and Reports</b>	<b>360 - 361</b>			X	X
Water Customer Reports	360			X	X
Utility or Agency Operating Records	360			X	X
Testing and Repair Personnel Reports	361			X	X
<b>Information Management and System Mapping</b>	<b>363 - 371</b>	<b>179 - 189</b>			
<b>Distribution System Maps</b>	<b>363 - 367</b>		X	X	X
Comprehensive Maps	363 - 364		X	X	X
Sectional Maps	364 - 366		X	X	X
Valve and Hydrant Maps	366		X	X	X
Plan and Profile Drawings	367		X	X	X
Map Symbols	367		X	X	X
<b>Equipment Records</b>	<b>367 - 370</b>		X	X	X
Valve Records	367		X	X	X
Hydrant Records	368 - 369		X	X	X
Service Records	369 - 370		X	X	X
Meter Records	370		X	X	X

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Information Management and System Mapping</b>	<b>363 - 371</b>	<b>179 - 189</b>			
Technical Information	370		X	X	X
<b>Geographic Information Management Systems</b>	370 - 371		X	X	X
<b>Automated Mapping/Facility Management/Geographic Information Systems</b>		179 - 183	X	X	X
Basic Elements of an AM/FM/GIS		179	X	X	X
System Software		180	X	X	X
Water Utility Applications		180 - 183	X	X	X
Water Resource Management		182	X	X	X
Customer Services		182	X	X	X
Operations		182	X	X	X
Water Demand Forecasting		183	X	X	X
Water System Modeling		183	X	X	X
<b>Maintenance Management</b>		183 - 188	X	X	X
Work Orders		183 - 184	X	X	X
Technical Information		184 - 185	X	X	X
Computerized Maintenance Management		185 - 188	X	X	X
Reporting		186	X	X	X
Preventive Maintenance		186	X	X	X
Equipment Histories		186	X	X	X
System Integration		186 - 188	X	X	X
<b>Other Major Information Systems</b>		188 - 189	X	X	X
Source-of Supply Systems and Treatment Plant Process Control Systems		188	X	X	X
Laboratory Information Management Systems		188	X	X	X
Leakage Control and Emergency Response		188 - 189	X	X	X
Customer Information Systems		189	X	X	X
<b>Safety, Security, and Emergency Response</b>	<b>373 - 380</b>	<b>191 - 202</b>			
<b>Personal Safety Considerations</b>	373 - 374				
Regulatory Requirements	373				
Causes of Accidents	373				
Personal Protection Equipment	373 - 374				
<b>Equipment Safety</b>	374 - 379				
Material Handling	374 - 375				
Trench Safety	375				
Confined-Space Safety	375 - 376				

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Safety, Security, and Emergency Response</b>	<b>373 - 380</b>	<b>191 - 202</b>			
Hand Tool Safety	377				
Portable Power Tools	377 - 378				
Traffic Control	378 - 379				
Chemical Safety	379				
Vehicle Safety	379				
<b>Water Supply System Security</b>	379 - 380		X	X	X
<b>Water Supply System Threats</b>		191 - 192	X	X	X
Cyber Threats	380	191	X	X	X
Physical Threats	380	191 - 192	X	X	X
Chemical Threats	380	192	X	X	X
Biological Threats	380	192	X	X	X
<b>Water Supply System Vulnerabilities</b>		192 - 194	X	X	X
Vulnerabilities of Water Supply Systems		192	X	X	X
Vulnerabilities of computer System Infrastructure		192 - 194	X	X	X
<b>Vulnerabilities Assessments</b>		194 - 195	X	X	X
SCADA Systems		194 - 195	X	X	X
<b>Early Warning Systems</b>		195 - 196	X	X	X
<b>Security Hardware and Surveillance Systems</b>		196 - 199	X	X	X
Intrusion Detection Systems		196 - 198	X	X	X
Closed-Circuit Television		198	X	X	X
Access Control Systems		198	X	X	X
Role of SCADA Systems for Security		198 - 199	X	X	X
<b>Emergency Response Plans</b>		200 - 202	X	X	X
Components of an ERP		200 - 202	X	X	X
<b>Public Relations</b>	<b>383 - 387</b>				
<b>The Importance of Public Relations</b>	383		X	X	X
<b>The Role of Public Relations</b>	383 - 384		X	X	X
<b>The Role of Water Distribution Personnel</b>	384 - 387		X	X	X
Meter Readers	384 - 385		X	X	X
Maintenance and Repair Crews	385 - 387		X	X	X
Public Relations Behind the Wheel	387		X	X	X
Public Relations and the Media	387		X	X	X
<b>Administration and Public Relations</b>		<b>205 - 229</b>			
<b>Managing System Operations</b>		205 - 211			

Topic	Grades 1&2 Page	Grade 3 & 4 Page	C	B	A
<b>Administration and Public Relations</b>		<b>205 - 229</b>			
Developing a System Operations Management Plan		206 - 208			
System Performance Assessment		206			
Performance Measures and Goals		207			
Operational Practices		207 - 208			
Management Plan Review and Revision		208			
System Operations Training		208 - 210			
Example Performance Measures		208 - 210			
Pipeline Rehabilitation and Replacement		210 - 211			
Pipeline R&R Plan		210 - 211			
Pipeline Inventory		211			
Performance Assessment and Tracking		211			
Planning and Prioritization		211			
Operational Considerations		211			
<b>Employee Management</b>		211 - 214			
Policies and Regulations		211 - 213			
Policies Affecting Supervisors		212 - 213			
Employment Laws		213			
Workplace Safety		213 - 214			
<b>Supervision of Operations</b>		214 - 223			
Defining Supervision		214			
Personnel Management		214 - 216			
Factors Affecting Supervision		216 - 217			
Supervisory Functions		217 - 223			
Planning and Budgeting		217 - 219			
Organizing and Staffing		219 - 220			
Directing		220 - 221			
Ensuring Efficient Communications		221			
Controlling		221 - 222			
Managing Time and Making Decisions		222 - 223			
<b>Budgets</b>		223 - 228			
<b>Formal Public Relations Programs</b>		228 - 229	X	X	X
Customer Service		228	X	X	X
Public Information		228 - 229	X	X	X
Media Relations		229	X	X	X



## North Carolina Rules Governing Public Water Supplies (*Green Book*)

<b>Subchapter 18C - Water Supplies</b>		C	B	A
<b>A. Section .0100 - Protection of Public Water Supplies</b>				
.0102 Definitions				
<b>B. Section .0300 - Submission of plans, specifications, and Reports</b>				
.0301 Applicability		X	X	X
.0303 Submission required by engineer and water supplier		X	X	X
.0304 Application for approval: by whom made				X
.0305 Approval of plans necessary before contracting				X
.0306 Changes in plans or specifications after approval				X
.0307 Engineer's report				X
.0308 Type and form of exhibits				X
<b>C. Section .0400 - Water supply design criteria</b>				
.0405 Storage of finished water		X	X	X
.0406 Distribution systems		X	X	X
.0407 Electrical systems		X	X	X
.0408 Lead free construction		X	X	X
.0409 Service connections		X	X	X
<b>D. Section .0600 - Raw surface water facilities</b>				
.0604 Pumps; Power facilities				X
<b>E. Section .0800 - Hydropneumatic storage tanks</b>				
.0801 Capacities; Determining minimum effective volume		X	X	X
.0802 Capacities; Determining peak demand		X	X	X
.0803 Capacities; Determining total volume		X	X	X
.0804 Capacities; Ground storage plus hydropneumatic tanks		X	X	X
.0805 Capacities; Elevated storage			X	X
<b>F. Section .0900 - Distribution systems</b>				
.0901 Size of the water mains		X	X	X
.0902 Number of residences on a water main		X	X	X
.0903 Dead-end water mains		X	X	X

	<b>Subchapter 18C - Water Supplies</b>		<b>C</b>	<b>B</b>	<b>A</b>
	.0904 Pipe laying		X	X	X
	.0905 Testing new water mains		X	X	X
	.0906 Relation of water mains to sewers		X	X	X
	.0907 Valves			X	X
	<b>G. Section .1000 - Disinfection of water supply systems</b>				
	.1001 Disinfection of new systems		X	X	X
	.1002 Disinfection of wells		X	X	X
	.1003 Disinfection of storage tanks and distribution systems		X	X	X
	.1004 Disinfection of filters				
	<b>K. Section .1800 - Local plan approval program</b>				
	.1801 Local approval program			X	X
	.1802 Application for certification			X	X
	.1803 Certification			X	X
	.1804 Notice			X	X
	.1805 Departmental enforcement			X	X
	<b>L Section .1900 - Administrative penalties</b>				
	.1913 Right of entry and inspection		X	X	X
	<b>M. Section .2100 - Operating permits</b>				
	.2101 Permits		X	X	X
	<b>Appendix A Guidelines</b>		X	X	X

## Rules Governing Water Treatment Facility Operators (*Blue Book*)

Subchapter 18D - Water Treatment Facility Operators		C	B	A
<b>A. Section .0100 - General Policies</b>				
	.0102 Organization	X	X	X
	.0103 Meetings of the Board	X	X	X
	.0105 Definitions	X	X	X
<b>B. Section .0200 - Qualification of applicants and classification of facilities</b>				
	.0201 Grades of certification	X	X	X
	.0202 Examinations	X	X	X
	.0203 Determination of various classes of certification	X	X	X
	.0205 Classification of water treatment facilities		X	X
	.0206 Certified operator required	X	X	X
<b>C. Section .0300 - Applications and fees</b>				
	.0301 Application for exam	X	X	X
	.0302 Application for reciprocity	X	X	X
	.0303 Application for temporary certificate	X	X	X
	.0304 Fee schedule	X	X	X
	.0305 Waiting period	X	X	X
	.0307 Revocation of certificate	X	X	X
	.0308 Professional growth hours	X	X	X
	.0309 Certification reinstatement	X	X	X
<b>D. Section .0400 - Issuance of certificate</b>				
	.0401 Notification of classification	X	X	X
	.0403 Issuance of grade certificate	X	X	X
	.0404 Temporary certificate	X	X	X
	.0405 Reciprocal certificates	X	X	X
<b>E. Section 0.500 - Rule making procedures</b>				
	.0501 Petitions	X	X	X
<b>F. Section .0600 - Contested cases</b>				
<b>G. Section .0700 - Operations and Management</b>		X	X	X
	.0701 Operator in Responsible Charge	X	X	X

	<b>Math Review Guide</b>	<b>Page</b>	<b>C</b>	<b>B</b>	<b>A</b>
	Percentages	4	x	x	x
	Conversions	5, 8, 10, 11	x	x	x
	Area	5-6	x	x	x
	Volume	5-6	x	x	x
	Slope	6-7	x	x	x
	Pressure/Head	8	x	x	x
	Average	3	x	x	x
	Velocity	4		x	x
	Flow Rate	4		x	x
	Force	8		x	x
	Temperatures	10			x
	Dosage (mg/l)	7-8			x
	Feed Rate (lbs/med)	7			x
	Contact Time	8			x
	Electricity	9			x
	Pumps (Horsepower)	9-10			x
	Conversion Factors & Constants	11	x	x	x